OPTICAL EMISSION SPECTROSCOPIC EXPERIMENTS FOR IN-FLIGHT ENTRY RESEARCH

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In the proposed paper, based on the emission spectroscopic payload RESPECT [1], developed for the European re-entry vehicle EXPERT [2], the applicability and benefits of emission spectroscopic payloads as part of the scientific instrumentation of re-entry vehicles will be discussed. Moreover, possible further development stages, enhancing the operational range and/or improving the scientific output of the instrument will be presented.

The instrumentation of re-entry vehicles with emission spectroscopic payloads is motivated by the significant interaction of the plasma state of post shock regime and boundary layer with the thermal and mechanical loads on the heat shield surface. Especially for re-entry missions in CO2 dominated atmospheres, as well as re-entry missions to the giant planets, the radiative heat flux contributes significantly to the total heat flux on the TPS surface. Information on the plasma state can be obtained by emission spectroscopic measurements. Although various numerical codes have been developed to simulate these conditions, the experimental data which can be used to verify the numerical simulations are still poor. Thus, in-flight measurements are most valuable to increase the reliability of the current data base and therewith the design base for future missions.

In the past years the payload RESPECT was developed at the Institut für Raumfahrtsysteme (IRS) to serve this purpose. Development, assembly and qualification of the payload for application on the European re-entry mission EXPERT were successfully completed and currently the flight model of the re-entry capsule is assembled. Thus, the focus of the payload related activities changes towards the preparation of the flight data analysis and the expected scientific output.

In order to judge the scientific output expected from the application of RESPECT on EXPERT, numerically simulated spectra were generated. These spectra have been calculated based on flow field simulations of several trajectory points, using the URANUS code [3], and superimposed radiation simulations using the plasma radiation data base PARADE [4]. In order to generate simulated spectrometer data sets the numerical radiation data was convoluted with the optical properties of the payload gained from laboratory experiments to characterize the instrument [5]. The expected results comprise among others the identification of the radiating plasma species including possible erosion products originating from the heat shield material. In addition, the occurrence of active oxidation of the ceramic heat shield can be traced on basis of the detected erosion products. Beyond that, from the numerical rebuilding of the measured spectra, the locally resolved plasma composition including particle densities and excitation temperatures shall be determined. The data is expected to allow for an accuracy analysis of the current simulation tools and the improvement of the employed chemistry and radiation models.

In this paper, based on the experience gathered in the development of the RESPECT sensor system an outlook on possible further development stages will be given. This includes the enhancement of the operational range as well as design improvements to maximize the scientific output. The payload was developed for the re-entry of EXPERT into Earth’s atmosphere but is also suitable for other planets. The limits of the sensor system with respect to the operation in other atmospheres and possibly required design modifications will be discussed. In addition, design improvements for future emission spectroscopic payloads, such as the application of other spectrometer types, and their impact on the measurement data and scientific output will be presented.

References

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